Berries…with a side of DNA?

A DNA Extraction Lab for Middle School

Maryland Loaner Lab Teacher Packet

TOWSON UNIVERSITY

Written and developed by Towson University and TIGR.

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Towson University's Center for STEM Excellence

Towson University's Center for STEM Excellence (TUCSE) primarily provides three services to educators and students. The Maryland Loaner Lab program develops inquiry-based, student centered, hands-on activities and lab kits aligned with state education standards. Curricula and supplemental resources are available for FREE on our website or by contacting program staff. The SciTech Student Learning Laboratory is housed in the Columbus Center in Baltimore's Inner Harbor and offers students the opportunity to experience biotechnology and Bay ecology first-hand in our dedicated student laboratory led by an expert instructor. TUCSE's Professional Development opportunities allow educators to expand their knowledge and experience in biotechnology, lab activities for students, Next Generation Science Standards, climate change and other areas. Please visit our website (www.towson.edu/cse) for more information or to register for any of our programs.

Overview

All living things are made of cells, and with the exception of mammalian red blood cells, all cells contain DNA. *Berries…with a side of DNA?* invites students to explore cell structure and the presence of DNA in living cells, especially in the cells of foods we eat.

This activity is divided into three parts, a **pre-laboratory,** a **laboratory** exercise, and a **post laboratory** activity. The goal of the pre-laboratory exercise is to engage students by making connections between some cell structures and analogous city structures and/or locations. This activity opens the door for modeling activities. The introductory activities include a short video which introduces cell theory and some cell structures to students, and concludes with students reading an article and problem-solving ways to work through the challenges encountered in extracting DNA. The laboratory exercise begins with students extending their problem-solving ideas by correctly ordering the steps involved in DNA extraction. The actual laboratory activity allows students to determine if DNA is in the food we eat by attempting to extract DNA from foods such as strawberries, onions, and bananas. The post laboratory activity asks students to analyze and interpret their data, then answer the initial investigative question with evidence from the lab and explained with reasoning.

Inquiry based instruction promotes exploration before explanation, encourages greater student engagement, and facilitates depth of learning. Inquiry based instruction incorporates a student-centered, student-driven approach to teaching. This lab models inquiry-based learning in part by engaging students with a real-world question, encouraging students to predict ways to solve the challenges associated with extracting DNA and by determining the order of the procedural steps.

Investigation Design

This lab investigation encourages students to review the basic elements of investigation design. In traditional laboratory experiments, scientists manipulate **independent variables** to determine the effects on the **dependent variables**. Other elements of the experiment remain consistent, and are termed "**constants**". But scientists need a reference point to compare their results. Specifically, they need to know what a "negative" result looks like and how it compares to a "positive" result. **Controls** serve as points of comparison for the investigation. In this investigation, a positive control shows what the sample will look like if DNA is extracted and isolated from the sample while the negative control lacks DNA.

Food Samples

Foods like strawberries, bananas, kiwis, raspberries, and onions work particularly well in this lab. DNA can be isolated and extracted from other foods such as meats, other produce, and even processed foods such as corn chips and crackers. Teachers and classes can choose to attempt isolations from a variety of foods, but the suggested produce is recommended because they provide reliable results with a high volume of DNA.

Berries…with a side of DNA? Learning Goals:

1. Use a model of a city to explain the functions of organelles. (Pre-lab)
2. Plan and carry out an investigation to answer the driving question, Is DNA in our food? (Laboratory activity)
3. Analyze and interpret data collected during an investigation on DNA extraction from food. (Laboratory activity)
4. Use evidence to construct an explanation that DNA is in our food, and that all living things are made of cells, so must have DNA. (Laboratory activity/Post Lab)

Thank you for using Maryland Loaner Lab's *Berries…with a side of DNA?* in your classroom! We sincerely hope you and your students enjoy this lab activity!

SAFETY: The classroom teacher must instruct students with basic laboratory safety rules and provide gloves and goggles for student use with the laboratory activity.

Supplied by the Teacher:

Description	Quantity	Comments
Fruit/Vegetable	varies	Per student group - ½ of a medium or large strawberry, ½-inch slice of banana, ¼ of a kiwi or the equivalent
Isopropyl or Ethyl Alcohol (70%)	80 ml per class	8 ml per group. Best if used chilled. Note: 70% isopropyl or ethyl alcohol will work, but 90% is preferred.
Zip-lock bag	10	1 for each group to prepare experimental sample
Distilled H_2O	90 ml/class	9 ml/lab station

The teacher must ALSO supply all of the materials for all non-lab activities associated with this investigation.

Contained in the Maryland Loaner Lab kit:

Description	Quantity	Comments	Must be Returned
Pipette pumps	10	Pump used with pipettes to measure liquids	Return
Plastic pipettes: -10 "DNA Buffer" -10 "Alcohol" -10 "Experimental" -10 "dH_2O"	40	Size: 10 ml; Each student group needs 4 pipettes – one of each	Discard
DNA Buffer	10 tubes	8 ml per "DNA Buffer" tube, 1 for each group	Discard
Empty 15 ml "alcohol" tubes	10 tubes	Fill with 8 ml of alcohol, 1 for each group	Discard
Empty distilled water (dH_2O) tubes	10 tubes	10 ml per tube, 1 for each group	Discard
Wooden sticks	10	1 for each group	Return unused only
Styrofoam racks	10	1 per group	Test tube racks
Plastic 250 ml beaker	10	1 per group.	Clean, dry and return
Strainers	10	1 per group	Clean, dry and return
Test tubes	30	(empty, unlabeled tubes) 1 for food sample, 1 for negative control and 1 for the salmon cell positive control	Clean, dry and return
Container Disinfectant Wipes	1		Return
Salmon cells for positive control	20ml/ class	Each group gets 2 ml in tube which students will label "+" (**Keep refrigerated**)	Discard
Sharpies	10	1 for each group	Return

A PowerPoint presentation on DNA Extraction to support this activity is available on the Maryland Loaner Lab page (https://www.towson.edu/fcsm/centers/stem/loanerlab/index.html).

Pre-laboratory Activity – 15 min (Engage and Explore):

1. Engage your students by showing them the cell organelle rap (https://www.youtube.com/watch?v=-zafJKbMPA8). Student should complete the chart summarizing the organelles and their functions. Alternatively, a second "What is DNA?" video is available for students to view and complete the chart. This second video goes into greater detail than the rap and may work well as a follow-up video (https://www.youtube.com/watch?v=zwibgNGe4aY).

2. To further engage your students, ask them to label the city "Cellville" footprint with function of the city structure and the analogous cell organelles, based on the organelle function.

3. Ask students where they find cells.

4. Show students some examples of living organisms and nonliving things and ask them to label which have cells in them.

5. Ask them if all of the living things that have cells would also have DNA in their cells. This transitions to the lab investigation.

Lab Activity – 30-45 min, plus lab procedure of about 40 min (Explore and Explain):

6. Remind students of the big question we want to explore in the lab: Is DNA in our food?

7. Allow students time to read the background information provided on the student sheets. Ask them how they might solve the problem of getting through the membranes and the plant cell wall. Have students review their cell organelle/city analogy charts and edit them with the new information learned from the reading.

8. The Background Reading ends with a brief discussion about hypotheses and controls. Students are asked to write a hypothesis and identify a positive control (beef or salmon cells) and a negative control (distilled water) before moving on to the Laboratory Activity.

9. Distribute the Laboratory Activity and invite students to review their hypotheses or predictions. Students should copy their prediction/hypothesis in the space provided at the top of the Laboratory Activity Worksheet.

10. Tell students that Dr. Meischer left his protocol for them to use, but that the students will need to figure out the order. Before class, print pages S-5 and S-7. Ask students to cut out the steps on page S-7 (they are out of order on page S-7) and then paste those strips in the correct sequence in the chart on page S-5. (Hint: have them think about what they read about with critical pieces for DNA extraction consideration).

11. The teacher can choose to confirm that the class has the strips in order or allow the class to proceed with the steps in the sequence the groups determined.

12. Move through the steps of the procedure. Each group of students should use one fruit. Fruit can be frozen and thawed or fresh. Strawberries, bananas, kiwis, and raspberries work very well. Students can also try other fruits and vegetables. Carrots produce good results but are difficult to mash.

Post Lab – 15 minutes (Explain):

13. The post-lab consists of a Claim-Evidence-Reasoning chart and follow up questions to assist students in arguing with the evidence.

    The CER is a claim-evidence-reasoning chart. For this piece, students should answer the question “Does food have DNA in it?” as the claim statement. They then use evidence from their investigation to support their claim. They must then provide the reasoning for how their evidence supports the claim. Many students find making the claim and finding the evidence relatively easy, but students may struggle with the reasoning piece. Alternatively, the post lab questions 1-3 also serve to have students answer the question and provide the evidence and reasoning for their answers.

Extension Activities – time varies:

14. Students can build a cell model and connect it to the lab activity. An example of an online cell modeling activity can be found on Cells Alive (http://www.cellsalive.com/cells/cell_model.htm), and AAAS – ScienceNetLinks has a two-part lesson for cell modeling and cells as a system (http://sciencenetlinks.com/lessons/cells-1-make-a-model-cell/).

15. Students can complete the Why Did I….? papers. Ask students to connect the lab procedures to the cell structures or DNA characteristics encountered during DNA extraction. These papers can be completed during the five minute wait period during the lab procedures or any point after the lab. Resources are available in the Extension Activity section.

16. Students could research other applications of DNA extraction and describe them. They could hypothesize or test other samples to see if other samples from living things produce as much DNA as the samples used in this activity.

Background Information for Teachers

Cells form the basic unit of life. Living things may consist of a single cell or a collection of many cells organized into tissues, organs and organ systems that function together to form a multicellular organism. Bacteria and some fungi, such as yeast, are unicellular. Plants, animals, and other fungi like mushrooms are all multicellular. Organisms are classified into two very broad categories depending on cell type. **Prokaryotic** cells are smaller, simpler cells with circular DNA that is not contained in a nucleus. Prokaryotes lack membrane-bound organelles and are frequently unicellular. Larger, more complex cells which contain a nucleus and other membrane-bound organelles are **eukaryotic** cells. Plants, animals, and fungi are all eukaryotic organisms.

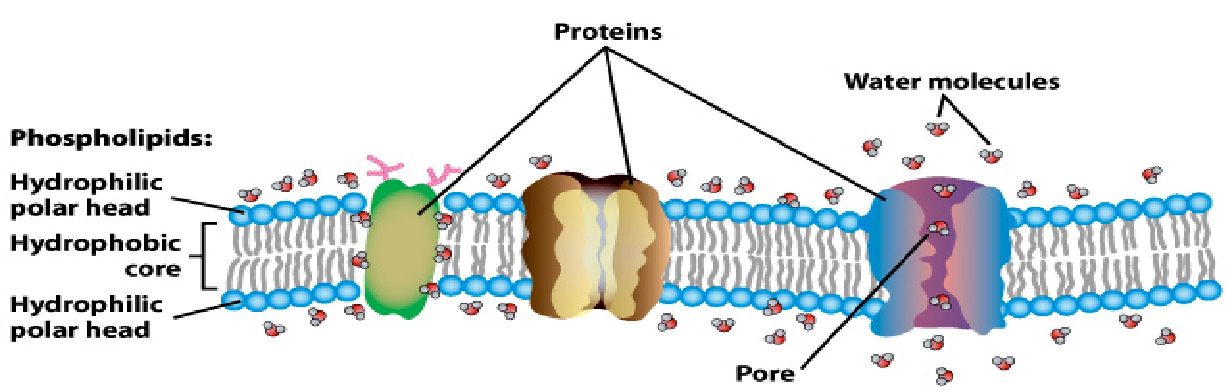
While significant differences exist between prokaryotic and eukaryotic cell structures, both cell types meet all of the requirements for the characteristics of life. Both contain the three primary parts of a cell. These three primary parts are

- **Cell membrane**, which serves as the barrier separating the cell from the outside world, regulates substances entering and leaving the cell, and communicates between the cell and the outside world.
- **Cytoplasm**, a jelly-like substance which fills the interior of the cell, and contains organelles and/or cell structures and dissolved substances necessary for cell functioning.
- **Deoxyribonucleic acid** or **DNA** is the genetic material that controls everything that happens in a cell.

Cell Membrane

The cell membrane consists of a phospholipid bilayer with proteins embedded in and on the surface of the membrane. Each phospholipid consists of a hydrophilic (polar, water-loving) head and a hydrophobic (non-polar, water-fearing) tail region. The hydrophobic tails orient towards each other to avoid the highly aqueous environment found in organisms. The proteins serve broad purposes. They can be cellular markers to identify the cell type, channels which regulate entry and exit of substances across the membrane, or receptors which bind to chemicals outside the cell to communicate external environmental conditions to the cell.

Eukaryotic cells also have a nuclear membrane. The nuclear membrane has the same basic structure as the cell membrane, but instead regulates what enters and leaves the nucleus. This provides an extra layer of protection for the eukaryotic cell's genetic material.



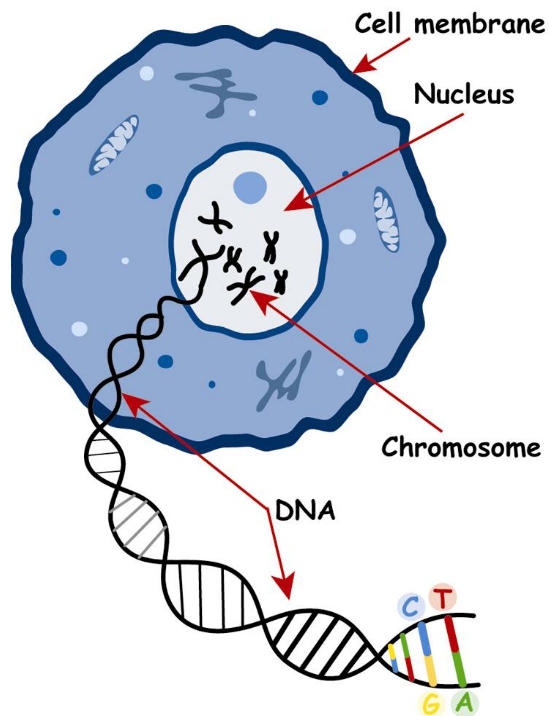
www.rise.duke.ed

Cytoplasm

All cells have a jelly-like substance called cytoplasm which fills the cell and suspends internal structures in the cell. Cytoplasm is highly aqueous with a water concentration of 65-95% depending on a variety of factors. Proteins, fat droplets, solid inclusions and dissolved substances necessary for cellular growth and functioning comprise the rest of cytoplasm's content.

DNA

DNA is the largest known molecule. A single unbroken strand can contain millions of atoms. DNA is made of two strands that wind around each other like a twisted ladder. The rungs of the ladder are made of the four nucleotides adenine (A), thymine (T), guanine (G) and cytosine (C). These nucleotides pair together, A-T and C-G. Different organisms have different sequences of these four nucleotides, but the pairings are consistent across all living things. The nucleotides "spell" out different genes, which are instructions to make particular proteins. Genes are organized on chromosomes; all of the chromosomes in a cell make up the organism's genome.



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DNA determines which proteins are made and directs all activities in the cell. Therefore, it also directs the entire multicellular organism. Prokaryotic cells possess a region of the cytoplasm called a nucleoid where the DNA is found. The nucleoid is not separated from the surrounding cytoplasm by a nucleus. In contrast, eukaryotic cells have a membrane-bound nucleus which contains the genetic information. This nucleus is generally found near the center of the cell, surrounded by cytoplasm.

DNA is found in all living cells except for mature mammalian red blood cells. During the maturation process, mammalian red blood cells lose their nucleus in order to accommodate a larger area for carrying hemoglobin for oxygen and carbon dioxide transport.

Isolating and Extracting DNA

Because DNA is essential in cells, it is not surprising that cells evolved ways to protect the genetic material. The process of extracting and isolating DNA requires that it be released from the cell. All cells have a cell membrane. Plant cells have an extra protective layer surrounding them called the cell wall. Mechanical destruction of the cell wall will readily remove it. Detergents and soaps break down cell membranes and proteins so that the DNA can be released. Protein enzymes of **proteases** like those in contact lens cleaner or "Ultra" forms of laundry detergents can be used to degrade proteins in cells and cell membranes.

Background Information for Teachers

When DNA is released from a cell it typically breaks into tiny fragments. These tiny fragments have a slightly negative electric charge. Salt ions, common in many solutions, are attracted to the negative charges of the DNA fragments and prevent them from adhering to one another. By controlling the salt concentration of the solution containing the DNA fragments, DNA can remain fragmented or become very “sticky” and form large globs of molecular material.

Once the DNA fragments are released into solution, the DNA can be spooled together by using ice-cold alcohol. A small layer of alcohol is added to the top of the solution containing cellular fragments. The DNA will collect at the interface between the alcohol and the cell solution. The DNA can then be captured or spooled onto a wooden stick or glass rod. The alcohol allows the DNA fragments to stick together once again and you have a blob of DNA to examine. Although this method is effective at isolating DNA, the DNA is by no means pure. Other materials like protein and cell fragments are carried along. Additional steps can be completed to remove proteins and cellular debris, thereby purifying the isolated DNA. DNA purification steps are not a part of this lab.

Laboratory Preparation & Instructions for Teacher

Prepare Student Stations (10):

- 3 unlabeled empty test tubes
- 3 labeled 15 ml tubes with the following:
  - DNA Buffer: 8 ml
  - Distilled Water (dH_2O): 10 ml
  - Alcohol: 8ml
- Plastic pipettes labelled "DNA Buffer", "Alcohol", "Food", and "dH_2O"
- 1 pipette pump
- Fruit/vegetable sample
- 1 zip-lock bag
- 1 250 ml beaker
- 1 strainer
- 1 wooden stick
- 1 test tube rack

Preparing Food Samples (fruit/vegetable): Fruits that work the best are strawberries, raspberries, kiwis or bananas. Soft, ripe fruit will give the best results. While the activity directs the students to prepare the fruit/vegetable solution, the teacher may prepare this in advance is there if a time constraint.

Provide the students with one of the following: ½ of a medium to large strawberry, ½-inch slide of banana, ¼ of a kiwi, or an equivalent amount of the fruit of your choice. Make sure students remove all of the air from the zip-lock bag while fruit is being crushed and mixed well with distilled water and DNA buffer. A mortar and pestle can be used instead of a zip-lock bag. **Make sure the fruit is well mashed**; you really want a fruit pulp liquid without solid chunks. Students will pour off ONLY the liquid (no solid parts) into a small beaker or cup (this mixture could be filtered through two layers of cheesecloth in a funnel if desired). Students should label one unmarked test tube "E", then pipette 2 ml of this liquid into the "E" test tube while trying to avoid seeds and/or solid pieces of fruit.

Negative Control: Distilled Water

Tubes for the negative control are provided with the MDLL kit and are labeled "-". Each student group will pipette 2 ml of distilled water into their negative DNA control tube.

Positive DNA Control Sample: Salmon Sperm Cells

The Maryland Loaner Lab will provide teachers with a salmon cell solution. Two capped conical tubes will contain approximately 15 ml of salmon cells. This will be used by the students as a positive control (keep refrigerated until ready to use). The teacher will add 2 ml of the salmon cells into 10 of the unlabeled test tubes (1/group). Students should label this tube "+" at the beginning of the lab period.

Your MDLL kit provides enough salmon solution and buffer for the number of class sets indicated on your reservation. The following directions are provided In the event that you would like to run an additional positive control or need additional buffer.

Salmon cell substitutions:

Place four one-inch cubes of calf thymus or beef liver in a blender. Add 90 ml of DNA Buffer and 210 ml of dH_2O and blend until the mixture is almost smooth. This step breaks apart the sample; the smoother the mixture, the better the DNA isolation results.

DNA Buffer:

Add the following into the dH_2O and stir well.

- 5 ml dishwashing liquid (Palmolive™ is recommended)
- 1.5 g salt (NaCl, non-iodized)
- 5 g baking soda ($NaHCO_3$)
- 120 ml distilled water (dH_2O), available at most grocery stores

DNA Isolation

The students will add 1 ml of DNA buffer to each food sample and to each control tube. Mix the contents well by "flicking" the tubes 2 or 3 times.

When adding the 2 ml of alcohol, pipette it slowly down the side of each test tube to form a layer that floats on top of the sample. It is best to add the alcohol while the tube is held at a slight angle. **DO NOT MIX OR INVERT THE TUBES** after adding alcohol. Gently place tubes in rack.

If there is DNA present in any of the samples, it should precipitate out at the interface between the two layers. Look for white or clear clumps; it may look like cobwebs or threads. There are often bubbles attached to the DNA. Students may use the wooded stick to spool the DNA clumps and place them on black paper for observation.

Results and Analysis

The students should record their observations after each step and their results. All produce samples should contain DNA. The salmon cells or beef liver extract sample should contain DNA and serve as the positive control. The distilled water sample should not contain DNA and is the negative control.

Students should refer to the initial investigative question and use the data collected from the lab to answer the question. A Claim-Evidence-Reasoning worksheet and follow up questions are provided in the post-lab to assist students with analyzing and interpreting their results. Have the students answer the investigation question, and ask them to consider if other foods would also contain DNA and why or why not.

Helpful Hints on using a Pipette Pump:

Secure the plastic pipette into the pump by using a pushing and twisting motion. Use the wheel to draw liquid into the pipette by rolling it forward; reverse the wheel's direction to expel the liquid. Always hold the pipettes upright when attached to the pump to prevent contamination and lost volume.

The 10 ml plastic pipettes have two scales on them, which run in opposite directions. When measuring liquid, use the scale that has the "1 ml" at the bottom of the tip and "10 ml" at the top. Also make sure to use the bottom of the meniscus (the curved part of the liquid in the pipette) to determine the volume level.

When transferring liquid, make sure the container you are transferring the liquid into is physically close to the container from which you are extracting the liquid. Liquids will sometimes drip out of the pipette tip, so the transfer must take place quickly.

The labeled pipettes should be used only with the corresponding liquids (they can be reused with the same liquid only), otherwise the pipettes and samples risk contamination and inaccurate results may be obtained. To further prevent contamination, the tip of the pipette should not touch the inside of the tubes when expelling liquid.

Berries…with a side of DNA?

Laboratory Steps, Notes & Answer to Steps Activity for Teacher

This steps sheet is for the teacher's use and should not be photocopies and distributed to students. This is the correct sequence for the steps that the students sort in the pre-lab activity. Teacher notes follow each step.

Step Number	Lab Step	Teacher Notes
1	**-Label one empty test tube "-", and the other one "E". -Put the experimental sample in the zip-lock bag - Add 7ml of "dH2O" (distilled water) to the bag.**	Fruit samples can be frozen and thawed. Softer, ripe fruits work well.
2	**- Use a clean pipette and add 3mL of DNA Buffer to the bag. - Remove the air from the bag and seal it.**	
3	**- Keeping the bag closed, gently mash up the food sample with the water and DNA buffer.**	Students are often enthusiastic about mashing their fruit samples. Remind them to mash carefully or the bag may break.
4	**- Carefully open the bag and pour off all of the liquid into the cup or beaker. Avoid getting any food chunks in the cup.**	Use the strainers to catch solids left after mashing the fruit.
5	**- Use a clean pipette to transfer 2 ml of food liquid from the beaker to a clean test tube marked "E" for experimental sample.**	
6	**- Transfer 2 ml of "dH_2O" to a test tube and mark it "–". - Note that 2 ml of positive control are already in the test tube. Mark it "+".**	Students will need to pipette the dH2O into the positive control. The teacher should aliquot the negative control prior to class.
7	**- Use a clean pipette to add 1 ml of DNA buffer to each test tube (food sample and both controls). - Mix gently by "flicking" them. - Wait 5 minutes.**	
8	**- After 5 minutes, slowly pipette 2 ml of alcohol into each test tube. Do NOT mix the test tubes. Watch for formation of a white or cloudy substance.**	Add the alcohol gently so it does not mix with the bottom layer. Cold alcohol works best, but room temperature will also work.

Berries…with a side of DNA? Name

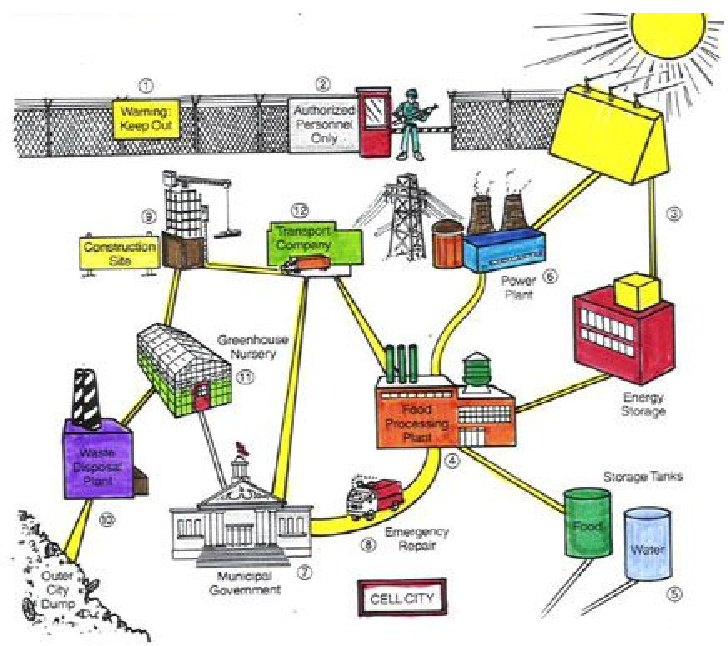
Answers to Student Worksheets

Pre-laboratory Activity – Student Sheet

1. Watch and listen to the cell rap to learn about cell organelle (https://www.youtube.com/watch?v=-zafJKbMPA8). Note the organelle's function in the space provided, and add any other notes.

Organelle	Function	Other notes
Nucleus	Contains DNA, "control center" of cell	Functions like Town Hall in Cellville
DNA	"Brains" of cells. Makes template for protein, determines characteristics of cell	Different species have different sequences. A-T, C-G are the four bases and how they pair.
Cell Membrane	Regulates what comes and goes in a cell; gate or gatekeeper of cell	
Mitochondria	Makes the energy for the cell. Powerhouse	

2. Imagine that cities are analogous to the structures of a cell. Use this footprint of Cellville City to label each building, its function, and the analogous cell structure. Be sure to include a key!

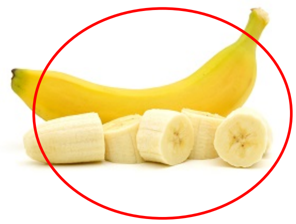
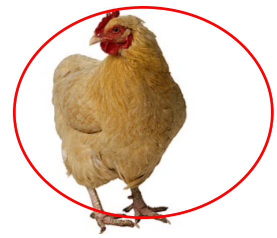


https://sites.google.com/site/davidbirdprovidencehigh/Home/courses/honors-biology/day-

3. Draw a circle around the items which have cells in them. Draw a square around the items which do not have cells in them.





4. If the circled items have cells, do they also have DNA?
If cells contain DNA and these things have cells, they should also have DNA.

What do you think:

Is DNA in our food?

Let's try to find DNA! Questions to consider as we try to find DNA: Do all cells have DNA? Do all organisms have DNA? Where could we find samples of DNA?

Driving question:

Does food have DNA in it?

Background Information: Back in 1869, Johann Friedrich Meischer developed a way to extract DNA from cells. He tested his procedures on salmon and beef cells and successfully extracted DNA. To extract DNA, scientists must break up each of the protective layers of the cell and carefully pull out the DNA hidden inside the nucleus. Each step of the extraction process either breaks up one of the layers or works with DNA to make it condensed, so the DNA is visible and thick enough to recover from the cell. It is kind of like a miniature mining mission!

Below are some considerations about extracting DNA from cells.

1. Plant cells have an extra layer on them that animal cells lack. This extra layer, called a cell wall, is a hard surface that helps protect the cell and maintain its shape. This layer must be broken down, but even in cells without a wall, the cells must be broken open so the inside contents are accessible. (See Figure 1.)

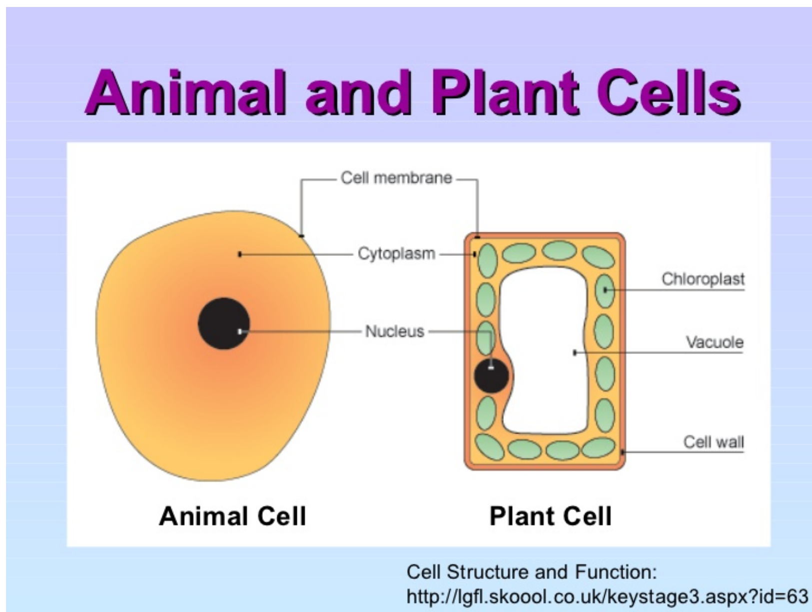


Figure 1. Which structures are common to both plants are animal cells? Which are only found in plant cells?

Question: How could you get through the cell wall?

Answers will vary, but students should recognize that they need to mechanically break up the cell wall for plant cells.

Answers to Student Worksheets

2. All cells have cell membranes. Membranes serve as a gateway for molecules leaving and entering the cells, and for communicating with the world outside of the cell. The membrane consist primarily of a double layer many molecules called phospholipids. The heads of the phospholipids are hydrophilic and associate with water. The tails of each phospholipid are hydrophobic and avoid water, instead associating with oils. Detergents consist of molecules which resemble a phospholipid. Detergents break up the phospholipid bilayer and disrupt the membrane. (See Figure 2).

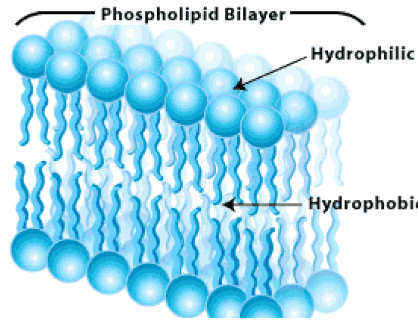


Figure 2. Why are the hydrophillic heads facing outside of the cell membrane?

Question: How could you get through the cell membrane?

Students should recognize that adding detergents would disrupt membranes.

3. Cells contain DNA, protein, carbohydrates, and other components. Successfully extracting the DNA means that the DNA is separated from the other cell components. Dr. Meischer discovered that adding salt to a mixture of DNA and cellular components causes the components to clump together and sink to the bottom of the test tube. DNA remains in suspension (stays in the liquid) until exposed to alcohol. (See Figure 3.)

Figure 3. The white or cloudy substance is DNA in the alcohol layer floating above an extract.

Question: Do you think you could add salt and alcohol in the same steps or in different steps? If you added them in different steps, which would you add first?

Students should recognize that salt must be added first, and alcohol second in order to make this work correctly. Our DNA buffer includes both salt and detergent.

YOUR Investigation:

After learning about their research topic, scientists make a prediction or **hypothesis** about what they think will happen in their experiment. Since you are a scientist investigating DNA in food, write your prediction or hypothesis about the presence of DNA in the food samples your class will test.

Answers will vary.

Experimental Design:

In order to know if you successfully extracted DNA, you'll want to compare your results to a known sample. You'll also want to know what it looks like if DNA is NOT successfully extracted. **Controls** are samples you run with known results. For example, your positive control will have DNA in it and your negative control will not have DNA in it. You do all of the same steps with your controls as you do with your **experimental samples** (the food you are testing for DNA).

What could you use as a negative control?

Distilled water because water is not living, so does not consist of cells nor contain DNA.

What could you use as a positive control?

Since Dr. Meischer used salmon and beef cells to test his protocol and successfully extracted DNA from both, we could use salmon or beef cells as our positive control.

Answers to Student Worksheets

Answers will vary. This is a possible answer for students.

Driving Question: *Does food have DNA in it?*

Claim (answer the question): *All foods may have DNA in them, but fruit and meat does have DNA in it.*

Evidence (What did you see in the lab to support your claim?):

DNA was successfully extracted from several fruit samples including strawberries, kiwi, and raspberries. DNA was also extracted from salmon cells in our lab and beef cells from Dr. Meischer's lab. We saw a white, cloudy substance in each of the test tubes with fruit or animal-based samples, and this substance was DNA. This is the evidence we have to support the claim.

Reasoning (Why does this evidence support this claim?):

We learned in our reading and videos that all living things are made of cells, and cells contain DNA. Therefore, food which was once living is made of cells and should contain DNA. The foods we tested were once living and are made of cells, and we successfully extracted the DNA, demonstrating that the DNA is still present in these foods when we would eat them. We did not test all foods, such as processed foods and fungi (mushrooms), so we cannot be certain if ALL foods contain DNA.

Questions: After completing the lab activity answer the following questions.

1. Did you successfully extract DNA from your sample? How did you know?
   Yes, we saw the white, cloudy substance in the alcohol layer.

2. Did your investigation today support that ALL of the food you eat has DNA in it? Why or why not?
   We can hypothesize that all foods that were once living contain DNA because so far, all food that was once living has had DNA in it. However, we did not test processed foods or mushrooms or vegetables, so we might want to test those before we can say that all foods contain DNA.

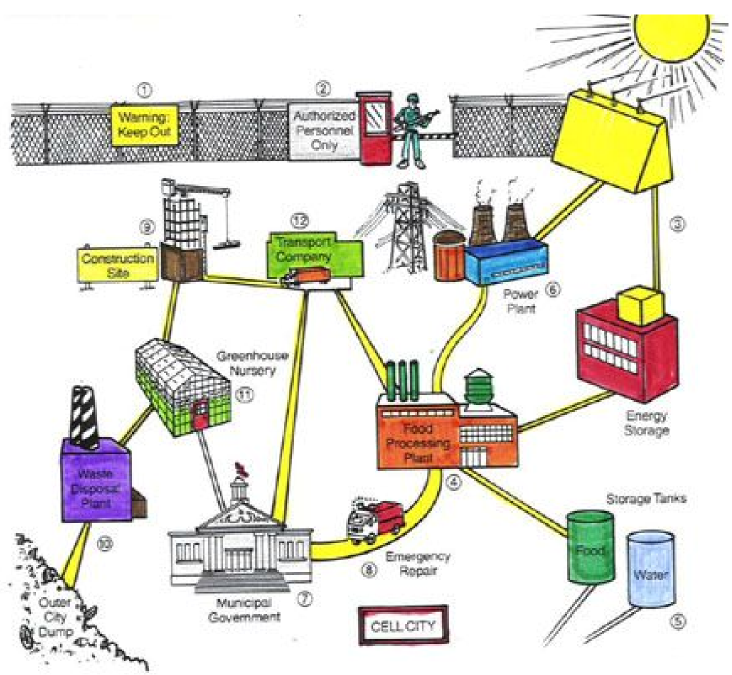
Pre-laboratory Activity – Student Sheet

Pre-laboratory Activity – Student Sheet

1. Watch and listen to the video(s). Note the organelle's function in the space provided, and add any other notes.

Organelle	Function	Other notes
Nucleus		
DNA		
Cell Membrane		
Mitochondria		

2. Imagine that cities are analogous to the structures of a cell. Use this footprint of Cellville City to label each building, its function, and the analogous cell structure. Be sure to include a key!



https://sites.google.com/site/davidbirdprovidencehigh/Home/courses/honors-biology/day-12/cell-city-assignment

3. Draw a circle around the items which have cells in them. Draw a square around the items which do not have cells in them.







4. If the circled items have cells, do they also have DNA?

What do you think:

Is DNA in our food?

Berries…with a side of DNA? Name

Background Reading for Students

Do everyday living things like the bananas, strawberries, chicken and fish have DNA in them? OR, to ask our driving question:

Is DNA in our food?

Background Information: Back in 1869, Johann Friedrich Meischer developed a way to extract DNA from cells. He tested his procedures on salmon and beef cells and successfully extracted DNA, but distilled water did not have DNA in it. To extract DNA, scientists must break up each of the protective layers of the cell and carefully pull out, or **extract,** the DNA hidden inside the nucleus. In order to do that, scientists need to get through each layer of the cell and recover the DNA. It is kind of like a miniature mining mission!

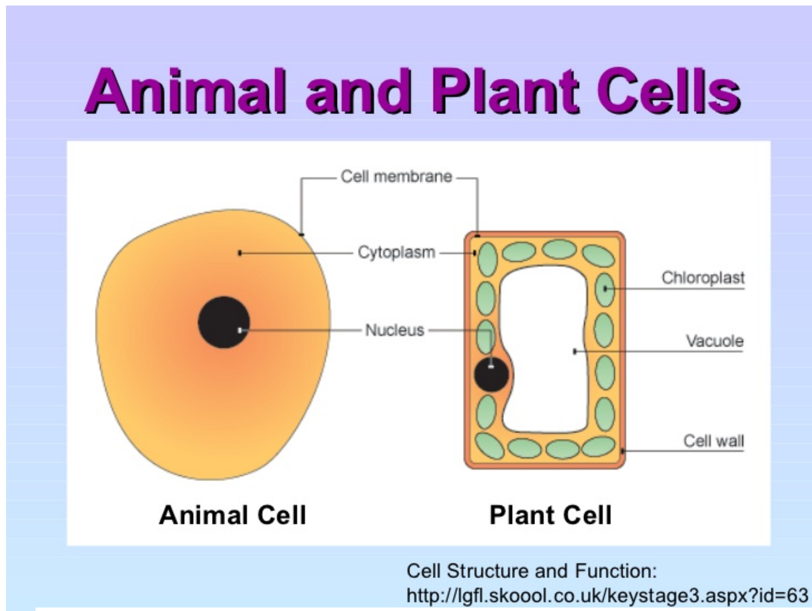


Figure 4. Which structures are common to both plants are animal cells? Which are only found in plant cells?

Below are some considerations about extracting DNA from cells.

4. The cell membrane is the outside layer of an animal cell, but plant cells have an extra layer. This extra layer, called a **cell wall**, is a hard surface that helps protect the cell and maintain its shape. (See Figure 1.)

   Question: How could you get through the cell wall?

5. All cells have a **cell membrane**. Membranes serve as a gateway for molecules leaving and entering the cells. They also communicate outside of the cell. The membrane consist primarily of a double layer many molecules called phospholipids. The heads of the phospholipids are **hydrophilic**, which means that they can form temporary bonds with water. The tails of each phospholipid are **hydrophobic** and avoid water. Detergents break up the phospholipid bilayer and disrupt the membrane. (See Figure 2).

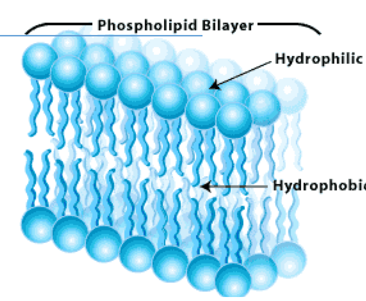


Figure 5. A cell membrane

Question: How could you get through the cell membrane?

6. Cells contain DNA, protein, carbohydrates, and other components. Successfully extracting the DNA means that the DNA is separated from the other cell components. Meischer discovered that adding salt to a mixture of DNA and cellular components causes the components to clump together and sink to the bottom of the test tube. Adding alcohol releases the DNA so it floats in the alcohol as seen in Figure 3.

   Question: Do you think you could add salt and alcohol in the same steps or in different steps? If you added them in different steps, which would you add first?

Figure 6. The white or cloudy substance is DNA in the alcohol layer floating above an extract.

YOUR Investigation:

After learning about their research topic, scientists make a prediction or **hypothesis** about what they think will happen in their experiment. Since you are a scientist investigating DNA in food, write your prediction or hypothesis about the presence of DNA in the food samples your class will test.

Experimental Design:

In order to know if you successfully extracted DNA, you'll want to compare your results to a known sample. You'll also want to know what it looks like if DNA is NOT successfully extracted. **Controls** are samples you run with known results. For example, your positive control will have DNA in it and your negative control will not have DNA in it. You do all of the same steps with your controls as you do with your **experimental samples** (the food you are testing for DNA).

What could you use as a negative control?

____

What could you use as a positive control?

____

Berries…with a side of DNA? Name

Laboratory Activity for Students

DNA Extraction Procedure & Observations: Copy or paste the steps in the correct order below. Write your observations in the Observations box after you complete each step.

Your hypothesis:

Step Number	Lab Step	Observations
1		
2		
3		
4		
5		
6		
7		
8		

Notes Page

Berries…with a side of DNA? Name

Steps Activity for Students

Directions: Use this activity with the Laboratory Activity for Students chart. Cut the following blocks out. Read each step and put the blocks in order to complete the DNA extraction activity.

- Keeping the bag closed, gently mash up the food sample with the water and DNA buffer.
- Use a clean pipette to add 1 ml of DNA buffer to each test tube (food sample and both controls). - Mix gently by "flicking" them. -Wait 5 minutes.
- Use a clean pipette to transfer 2 ml of food liquid from then to a clean test tube marked "E" for experimental sample.
- Use a clean pipette and add 3mL of DNA Buffer to the bag. - Remove the air from the bag and seal it.
- After 5 minutes, slowly pipette 2 ml of alcohol into each test tube. Do NOT mix the test tubes. Watch for formation of a white or cloudy substance.
-Label one empty test tube "-", and the other one "E". -Put the experimental sample in the zip-lock bag - Add 7ml of "dH2O" (distilled water) to the bag.
- Transfer 2 ml of "dH_2O" to a test tube and mark it "– ". - Note that 2 ml of positive control are already in the test tube. Mark it "+".
- Carefully open the bag and pour off all of the liquid into the cup or beaker. Avoid getting any food chunks in the cup.

Investigation Question: *Does food have DNA in it?*

Claim (answer the question):

Evidence (What did you see in the lab to support your claim?):	**Reasoning** (Why does this evidence support this claim?):

Questions: After completing the lab activity answer the following questions.

1. Did you successfully extract DNA from your sample? How did you know?

2. Did your investigation today support that ALL of the food you eat has DNA in it? Why or why not?

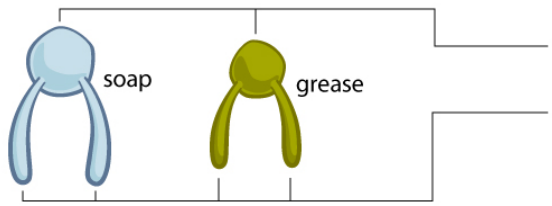
Why Did I…..?

DNA Buffer (DETERGENT)?

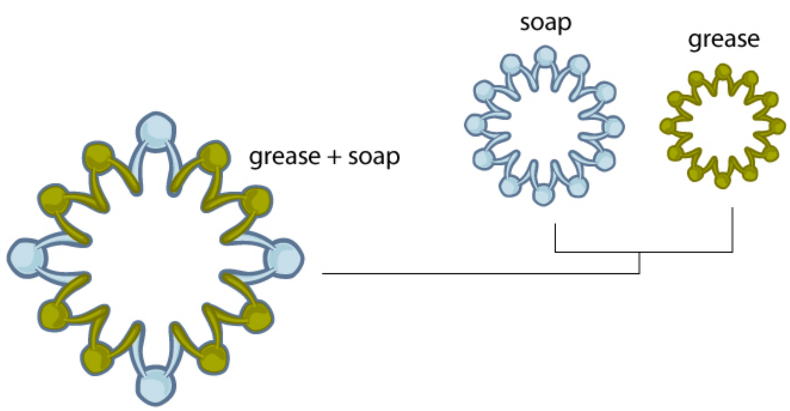
Each cell is surrounded by a sack (the cell membrane). DNA is found inside a second sack (the nucleus) within each cell. To see the DNA, we have to break open these two sacks. We do this with detergent. Why detergent? How does detergent work?

Think about why you use soap to wash dishes or your hands. To remove grease and dirt, right? Soap molecules and grease molecules are made of two parts:

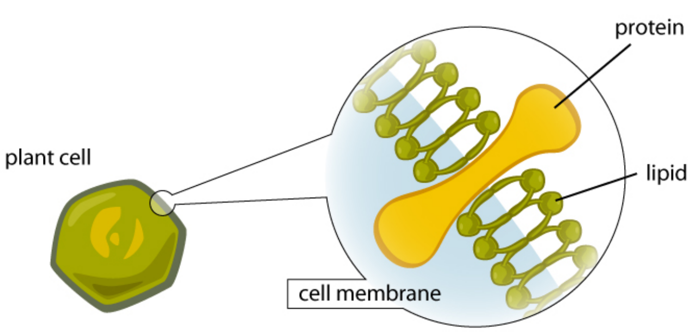
1) Heads, which like water.
2) Tails, which hate water.



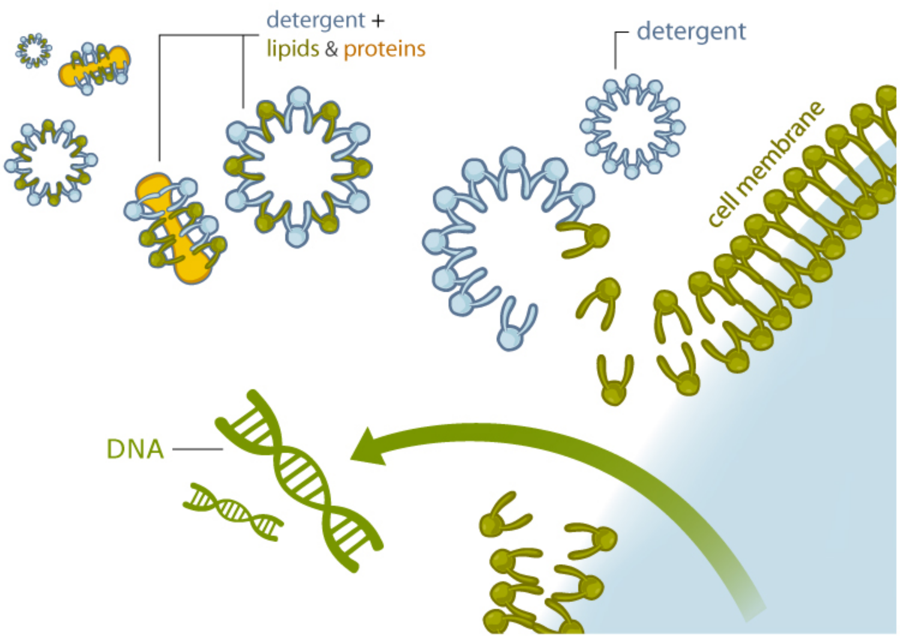
Both soap and grease molecules organize themselves in bubbles (spheres) with their heads outside to face the water and their tails inside to hide from the water.



When soap comes close to grease, their similar structures cause them to combine, forming a greasy soapy ball.



A cell's membranes have two layers of lipid (fat) molecules with proteins going through them. When detergent comes close to the cell, it captures the lipids and proteins. After adding the detergent, what do you have? The cell and nuclear membranes break apart, releasing the DNA from the cell.



(From: http://learn.genetics.utah.edu/content/labs/extraction/howto/detergent.html)

WHY DID I ADD SALT (NaCl)?

The salt then separates the proteins and other cellular debris from the DNA by causing them to clump together and sink to the bottom of the tube, while the DNA remains suspended in the liquid.

WHY DID I ADD ALCOHOL?

The addition of alcohol allows the DNA to precipitate, or fall out of solution, and form clumps that look like gooey globs or cobwebs.

<u>Questions</u>:

Extension Activity

1. In your own words, explain why DNA Buffer (detergent) is added to your samples. (What did the detergent do?)

2. In your own words, explain why a salt solution was added to the sample.

3. In your own words, explain the purpose of the alcohol added to your sample.

Performance Expectations: Students abilities to complete the following performance expectations will be supported by participation in this activity.

MS-LS1-1: Conduct an investigation to provide evidence that living things are made of cells; either one or many different numbers and types of cells.
MS-LS1-2: Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.

Dimension	Name or NGSS code/citation	Matching student task or question taken direction from the activity
Science and Engineering Practices	Planning and Carrying Out Investigations • Plan an investigation individually and collaboratively, and in the design identify independent and dependent variables and controls, what tools are needed to do the gathering, and how many data are needed to support a claim. • Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.	Students use reasoning skills to sequence the steps of the protocol to carry out the investigation to answer the driving questions, "Does food have DNA in it?" Students identify positive and negative controls, and write their hypotheses for their investigation.
	Analyzing and Interpreting Data • Analyze and interpret data to provide evidence for a phenomena.	Students analyze and interpret data from their and the class's DNA extractions to determine if food has DNA in it.
	Constructing Explanations • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including students' own experiments) and the assumption that theories and laws that describe	Students construct a scientific explanations using reasoning and evidence from their investigation to answer the driving question "Does food have DNA in it?".

	the natural work operate today as they in the past and will continue to do so in the future.	
Disciplinary Core Ideas	**LS1.A Structure and Function** • All living things are made of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.	Students explore in the pre-laboratory activity that living things are made of cells and that all living things have DNA in their cells. Students investigate whether food has cells and thus DNA by conducting DNA extraction and answering the driving question, "Does food have DNA in it?" Students fill in a chart to make the connection between the organelle and its function Students use a city as a model for a cell, correlating the city structures and locations to cell organelles.
Crosscutting Concepts	Structure and Function Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.	The pre-laboratory asks students to identify the function of cell organelles, then correlate those organelles to city structures and locations based on functions. Students are asked to explore if all cells would have DNA in them, and specifically test if food has DNA in it. Students construct an explanation that food does have DNA in it because food has cells and all cells have DNA, and students know this because of the evidence they gather in the investigation.
Nature of Science • Scientific investigations use a variety of methods		

Next Generation Science Standards

– New technologies advance scientific knowledge. • Scientific knowledge is based on empirical evidence
Connections to Common Core State Standards:
RST.6-8.3 *RST.6-8.10* *SL.8.1* *WHST.6-8.1*

Video and Online Resources

Other Video Resources:

Discovery Video – Cells (https://www.youtube.com/watch?v=u54bRpbSOgs)

What is a cell? - https://www.youtube.com/watch?v=3BZEA4areBM

What is DNA? How Does it Work? - https://www.youtube.com/watch?v=zwibgNGe4aY

Organelle Songs:

The Cell Song by Mr. W: https://www.youtube.com/watch?v=rABKB5aS2Zg

The BEST Cell Rap – with Lyrics: https://www.youtube.com/watch?v=CdGpsDF2Ci8

Online Resources:

BioMan: http://www.biomanbio.com/GamesandLabs/Cellgames/Cells.html

CellsAlive: http://www.cellsalive.com/cells/cell_model.htm